Fig. 2 illustrates a block diagram of the internal components of a navigation device formed in accordance with an embodiment of the present invention.

Fig. 3 illustrates a graphical representation over time of a user elevation trajectory, and associated GPS elevation readings and barometric altimeter readings.

Fig. 4 illustrates a processing sequence carried out in accordance with at least one embodiment of the present invention.

Fig. 5 illustrates a flow chart setting forth a processing sequence carried out in accordance with an embodiment of the present invention.

IN THE CLAIMS

1. A navigation device comprising:

a barometric altimeter for obtaining barometric elevation readings based on barometric pressure measurements;

a processor for providing GPS elevation readings based on GPS measurements, said processor calculating differences between said barometric elevation readings and said GPS elevation readings;

a filter filtering said differences to produce a barometer correction quantity, said filter being adjustable between a short time constant and a long time constant based on a time lapsed since a predetermined event; and

said processor correcting said barometric elevation readings based on said barometer correction quantity.

2. The navigation device of claim 1, further comprising a calibration unit calibrating said barometric altimeter based on said barometric altitude correction quantity continuously while simultaneous providing navigation information.

3. A navigation device comprising:

a barometric altimeter for obtaining barometric elevation readings based on barometric pressure measurements;

a processor for providing GPS elevation readings based on GPS measurements, said processor calculating differences between said barometric elevation readings and said GPS elevation readings;

a filter filtering said differences to produce a barometer correction quantity, said filter being adjustable between a short time constant and a long time constant;

said processor correcting said barometric elevation readings based on said barometer correction quality; and

a statistical model of barometric altimeter errors represented expected drift in the barometer elevation reading over a time lapsed since the device was last turned on, said filter adjusting filter characteristics between high and low gain based on said statistical model.

4. The navigation device of claim 1, wherein said filter performs the filtering operation based upon one of multiple sets of filter gain parameters, said processor setting said filter, when initially turned to one of said multiple sets of filter gain parameters based upon an elapsed time since said barometric altimeter was last calibrated.

5. The navigation device of claim 1, wherein said filter uses a first set of filter gain values to perform short-term averaging of said differences and a second set of filter gain values to perform long-term averaging of said differences.

6. A navigation device comprising:

a barometric altimeter for obtaining barometric elevation readings based on barometric pressure measurements;

a processor for providing GPS elevation readings based on GPS measurements, said processor calculating differences between said barometric elevation readings and said GPS elevation readings;

a filter filtering said differences to produce a barometer correction quality, said filter being adjustable between a short time constant and a long time constant;

said processor correcting said barometric elevation readings based on said barometer correction quality; and

a statistical model of anticipated errors in said barometric elevation readings, said filter using low gain when said statistical model indicates that an anticipated error is small, said filter using high gain when said statistical model indicates that an anticipated error is large.

7. The navigation device of claim 1, wherein said processor and filter calibrate said barometric altimeter while the navigation device is in motion during which elevation changes.

8. The navigation device of claim 1, wherein said processor and filter continuously calculate said barometric altimeter correction quantity throughout operation while in a navigation mode.

9. The navigation device of claim 1, wherein said barometric altimeter calculates barometric elevation readings based on an atmosphere model correlating barometric pressure readings to particular elevations, said processor adjusting said atmosphere model continuously throughout operation based on said barometric altimeter correction quantity.

10. The navigation device of claim 1, further comprising an atmosphere model associating barometric pressure measurements to elevations, said processor adjusting said atmosphere model at least once during operation by recalculating said elevations associated with said barometric pressure measurements based on said differences between said barometric elevation readings and GPS elevation readings.

11. In a navigation device, a method for estimating altitude based on measurements from a barometric sensor and measurements from a GPS receiver, comprising:

obtaining a first elevation based on barometric pressure measurements;

obtaining a second elevation based on GPS coordinate information;

calculating a difference between said first and second elevations;

utilizing a state feedback loop to drive said difference between said first and second elevations to zero; and

calculating an estimated altitude based on an output of said state feedback loop and said first elevation.

12. The method of claim 11, further comprising:

computing at least two gain values defining a rate at which said state feedback loop converges to zero; and

using one of said at least two gain values in said state feedback loop.

13. The method of claim 11, further comprising selecting a gain value from a set of multiple gain values, said selected gain value controlling a rate at which said state feedback loop converges to zero.

14. The method of claim 11, wherein said state feedback loop continuously updates said altitude calculated based on said first elevation and said output of said state feedback.

15. The method of claim 11, wherein said state feedback loop updates, at discrete intervals non-continuously, said altitude calculated based on said first elevation and said output of said state feedback.

16. A method for estimating altitude based on GPS and barometer measurements, comprising:

upon start up, determining a time lapse since last calibration of barometric altitude;

obtaining from a barometer drift model, an expected error in barometer readings based on the time lapse since last calibration; and

obtaining an estimated altitude based on the expected error.

17. The method of claim 16, further comprising:

generating the barometer drift model based on a statistical analysis of barometric pressure data collected over a period of time at a known elevation.

18. A method for estimating altitude based on GPS and barometric measurements, comprising:

deriving a barometric altitudefrom a barometer pressure measurement and an atmospheric pressure model;

deriving a GPS altitude from GPS information;

correcting said barometric altitude based on a coarse calibration of the atmospheric pressure model to obtain a coarse estimated barometric altitude; and

after obtaining the coarse estimated altitude, correcting the barometric altitude based on a difference between the course estimated barometric and GPS altitudes to obtain a fine estimated altitude.

19. The method of claim 18, further comprising:

adjusting an initial base pressure of the atmospheric pressure model toward a standard pressure value based on an amount of uncertainty in the barometric altitude.

20. The method of claim 18, further comprising:

adjusting an initial base pressure of the atmospheric pressure model toward a standard pressure value based on an amount of uncertainty in the GPS altitude.

21. A method for correcting a barometer altitude reading of a navigation device, comprising:

deriving a barometer-based altitude;

calculating a GPS-based altitude;

determining an expected drift error representing an amount of drift anticipated in said barometer-based altitude based on a model of drift error;

calculating a correction quantity based on convergence of a baro-GPS relation between said barometer-based and GPS-based altitudes toward a steady state value;

adjusting a rate of said convergence toward said steady state value based on said expected drift error; and

correcting a barometer altitude reading based on said correction quantity.

22. The method of claim 21, further comprising:

determining an elapsed time since a last calibration operation, said calibration operation improving an accuracy of said barometer-derived altitude, said expected drift error being determined based on said elapsed time.

23. The method of claim 21, further comprising:

upon turning the device on, identifying an elapsed time since last calibration, wherein said determining step obtains expected drift error from said model of drift error based on said elapsed time.

24. The method of claim 21, further comprising:

creating a model of drift error based on a statistical analysis of pressure measurements taken over an extended period of time.

25. The method of claim 21, further comprising:

comparing said expected drift error to a threshold and setting said rate of convergence to one of fast and slow time constants based on said comparison.

B7

26. The method of claim 21, further comprising:

comparing said expected drift error to a threshold; and

filtering said barometer-based and GPS-based altitudes based on one of fast and slow time constants.

27. The method of claim 21, further comprising:

filtering said baro-GPS relation between said barometer-based altitude and GPS-based altitude at one of high and low gain that is adjusted based on said expected drift error.

28. The method of claim 21, further comprising:

calibrating an atmospheric pressure model used to derive barometer-based altitude during said step of calculating said correction quantity.

29. The method of claim 21, further comprising:

coarsely filtering said baro-GPS relation when said expected drift error is above a predetermined threshold; and

finely filtering said baro-GPS relation when said expected drift error is below said predetermined threshold.

30. The method of claim 21, further comprising:

performing a steady state filter operation on a difference between said barometer-based and GPS-based altitudes based on one of high and low gain factors.

31. The method of claim 21, further comprising:

performing fast and slow convergence to calculate said correction quantity; and

switching between said fast and slow convergences based a relation between a vertical uncertainty of said GPS-based altitude and an amount of convergence of said baro-GPS relation.

32. The method of claim 21, further comprising:

filtering said baro-GPS relation; and

changing between high and low gain in said filtering step based on a degree to which said filtering step tracks said baro-GPS relation.

33. The method of claim 21, further comprising:

adjusting an initial model based pressure used to derive said barometer-based altitude between a standard base pressure and a measured base pressure.

34. The method of claim 21, further comprising:

adjusting an initial model base pressure relative to a standard base pressure as a function of an amount of uncertainty in said expected drift error.

35. A method for correcting a barometric altitude reading of a navigation device, comprising:

measuring barometric pressure;

calculating barometric altitude from an atmospheric pressure model and said barometric pressure;

re-calibrating said atmospheric pressure model by changing a model base pressure as a function of said barometric pressure and said barometric altitude; and

correcting said barometric altitude based on said re-calibrated atmospheric pressure model.

36. The method of claim 35, further comprising:

filtering noise from said barometric altitude in fine and coarse calibration operations, said re-calibrating step being performed at least once each time said fine calibration operation is performed.

Remarks

Claims 1-36 remain pending in the present application, of which claims 1, 3, 6, and 18-20 have been amended. It is respectfully submitted that the pending claims define allowable subject matter.

Beginning with the objection to the drawings, a proposed drawing change is submitted herewith to correctly label the housing 12 in Figure 1 and to label the GPS receiver as element 24 in Figure 2. The proposed drawing changes do not add new subject matter.